RICH Detector for Particle Identification in the EIC Forward Region – *eRD11*

Progress Report – January 2015
Period: October 1 – December 31, 2014

Carl Zorn*
Jefferson Laboratory
Newport News, VA

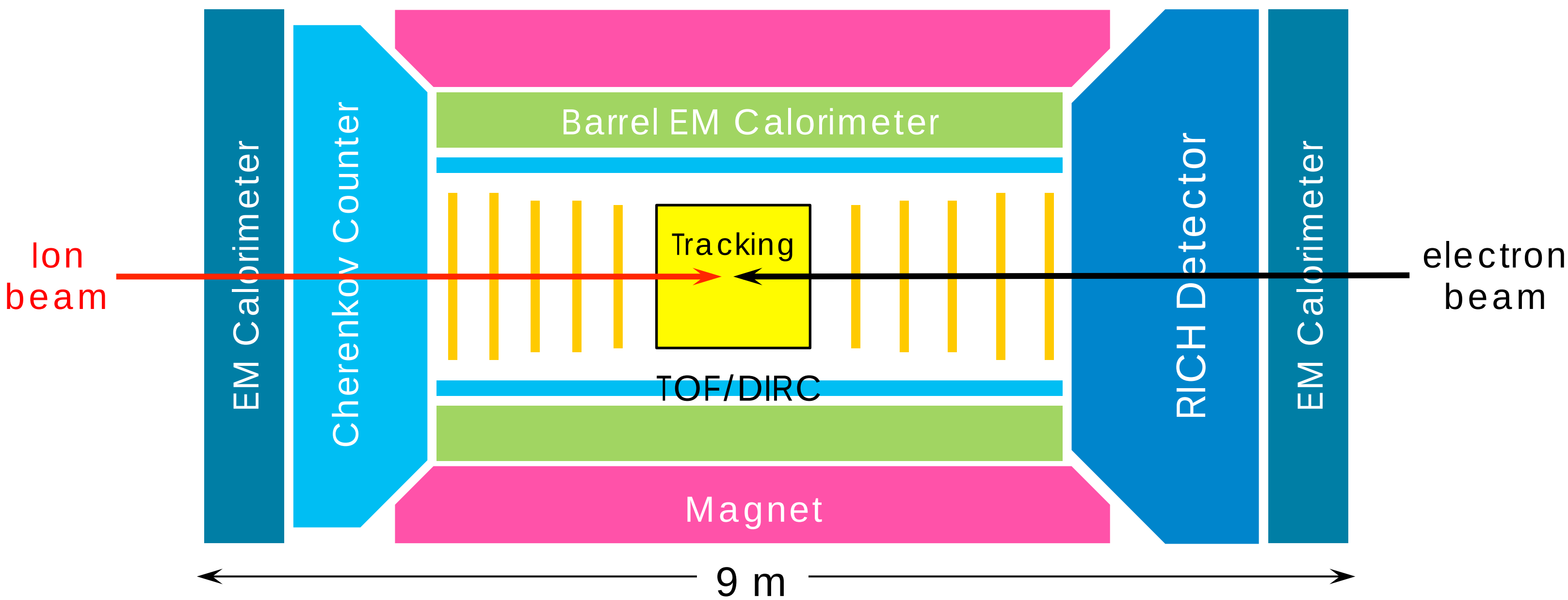
**on behalf of EIC/RICH eRD11 collaboration*

ERD11 Collaboration

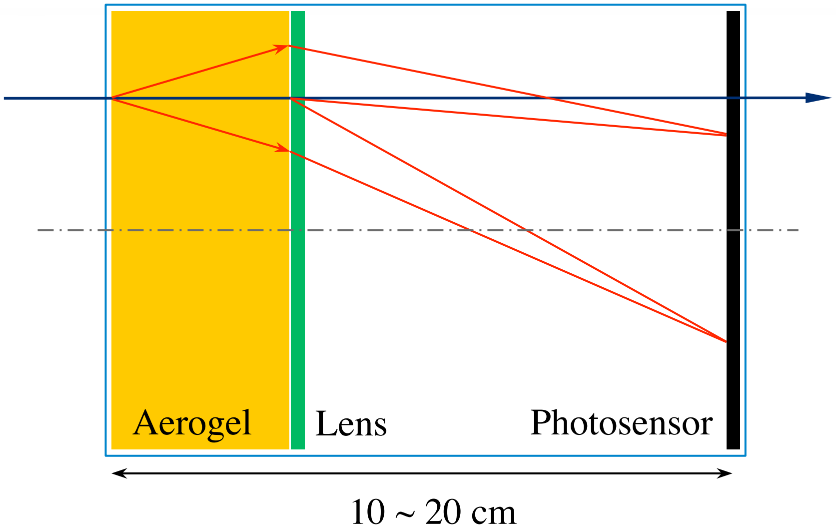
Fernando Barbosa, William Brooks, Marco Contalbrigo, Amaresh Datta, Marcel Demarteau, J. Matthew Durham, Douglas Fields, Xiaochun He, Hubert van Hecke (co-PI), Jin Huang, Ming Liu, Jack McKisson, Rodrigo Mendez, Yi Qiang (co-PI), Patrizia Rossi, Murad Sarsour, Robert Wagner, Jingbo Wang, Cheuk-Ping Wong, Wenze Xi, Liang Xue, Beni Zihlmann, Zhiwen Zhao, Carl Zorn

EIC PID Requirements

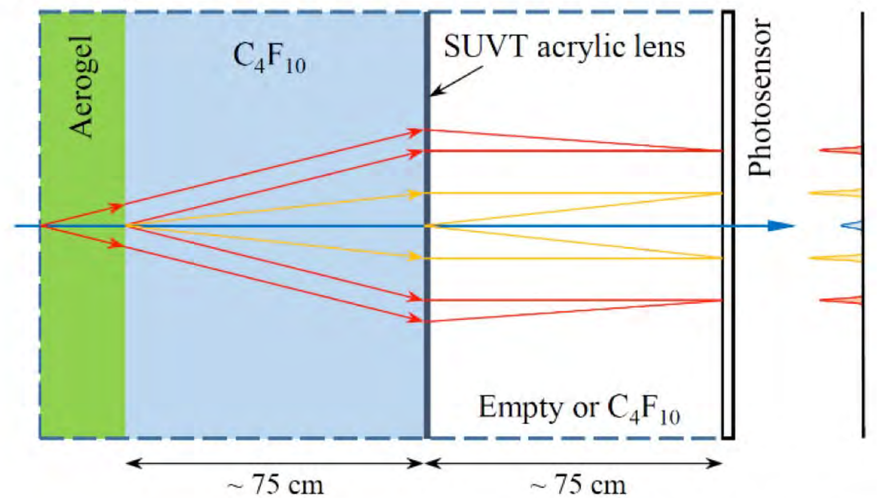
- Very rich physics program:
  - Nucleon tomography and spin structure
  - Quark hadronization
  - Spectroscopy
  - Many more …
- Dedicated EIC machine and spectrometer
  - Hermetic detector system
  - Large momentum range
  - Multi-particle detection in final states



Modular Concept – Dual Radiator



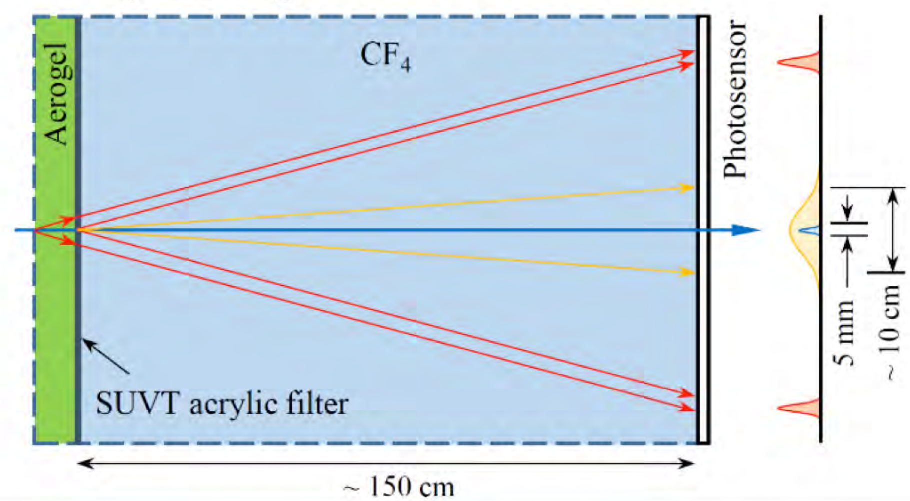
Focusing

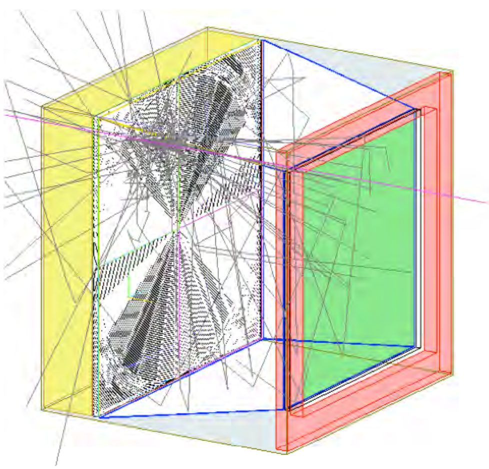


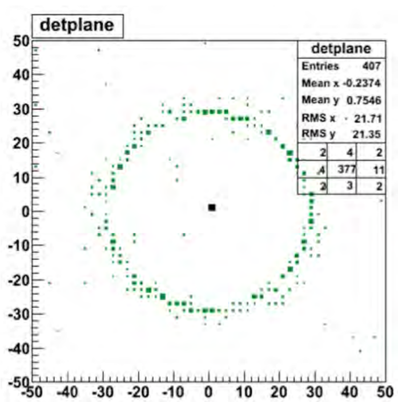
Source of Cherenkov lights

Aerogel Gas Glass window

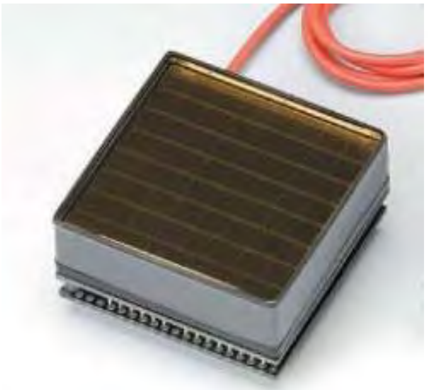
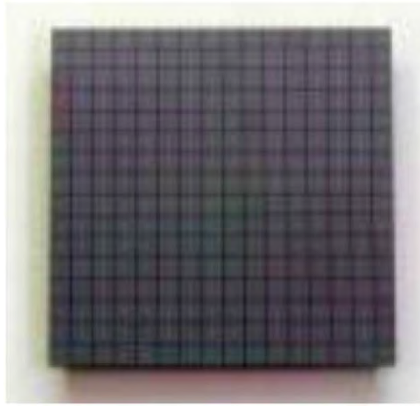
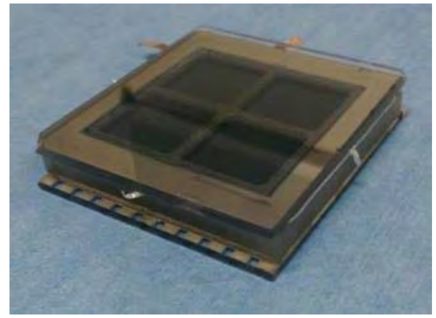
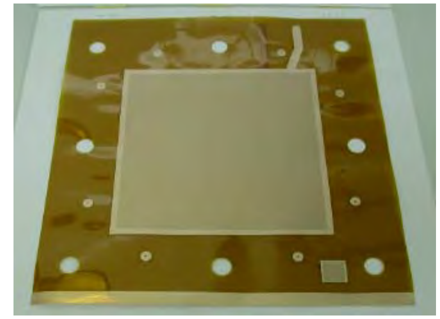
Proximity Focusing







Options for Readout

	MaPMT	SiPM	MCP-PMT	GEM
Cost	~ $1M/m^2	~ $1M/m^2	Low	Low
Position resolution	~ mm	~ mm	~ mm	~100 μm
Time resolution	fair	good	very good	poor
Dark rate	low	high	low ?	fair
Single photon detection	fair	good	fair ?	poor
Rate capability	good	good	fair ?	good
Radiation hardness	good	poor	good ?	good
Field sensitivity	poor	very good	fair ?	good

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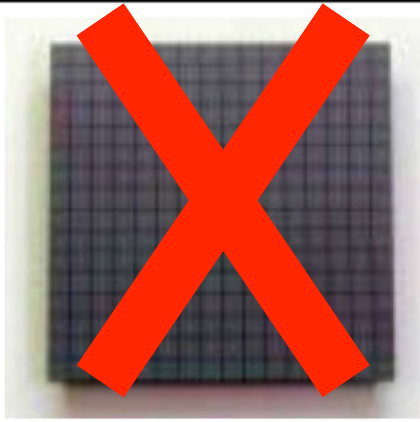

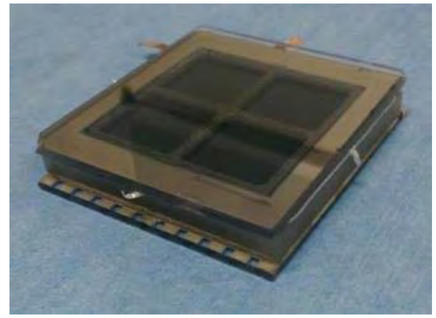

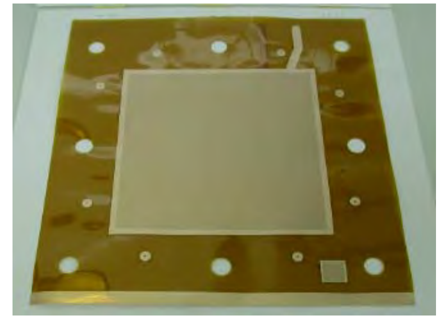

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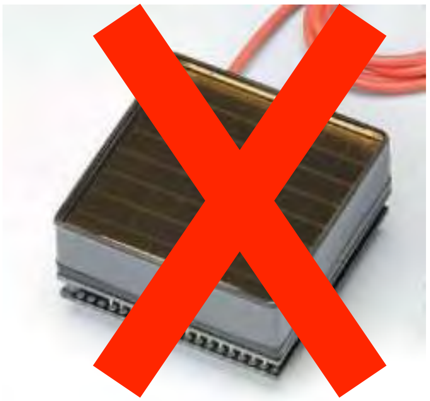

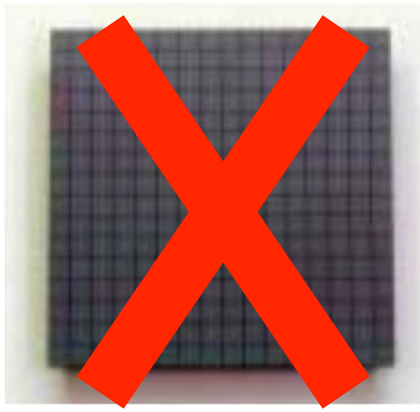

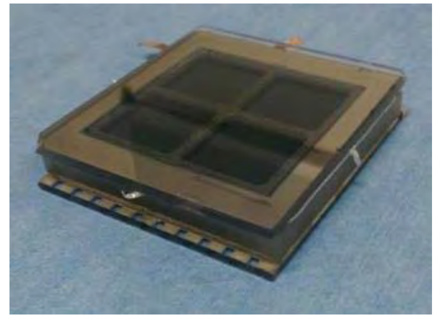

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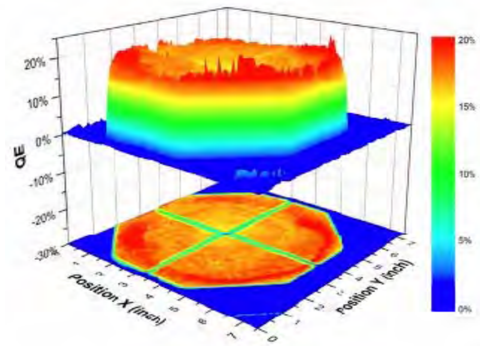
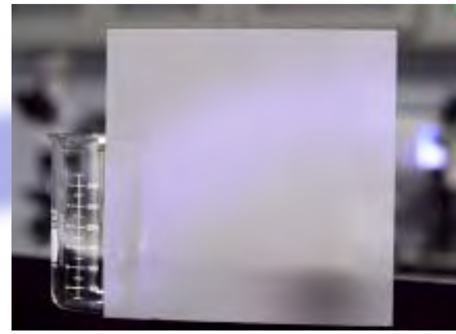
MCP-based LAPPD

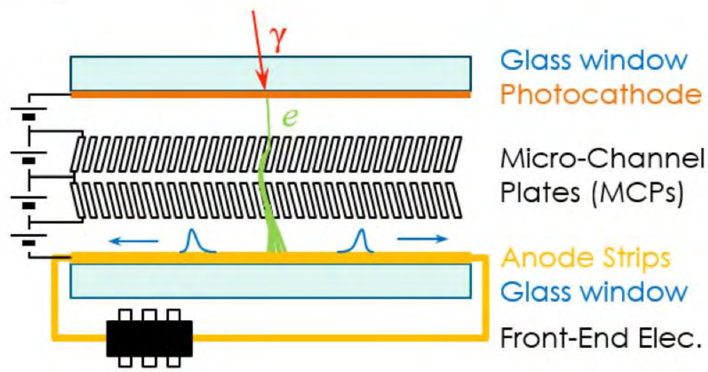
large area photocathode

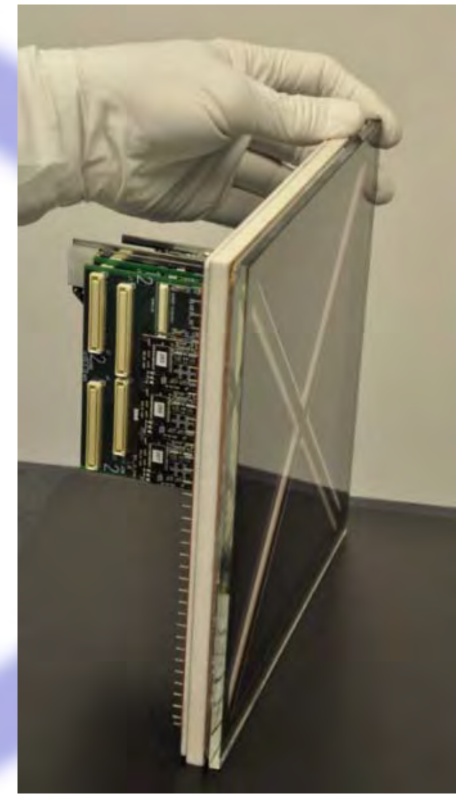




ALD MCP
1.2 mm
20 μm pore

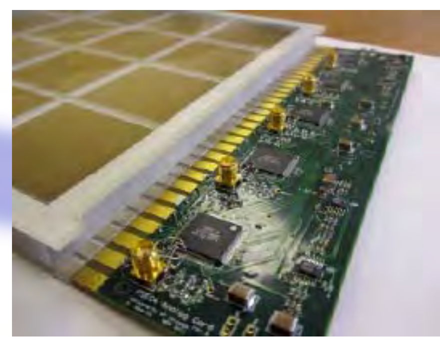
vacuum transfer system





$20 \times 20\ \text{cm}^2$

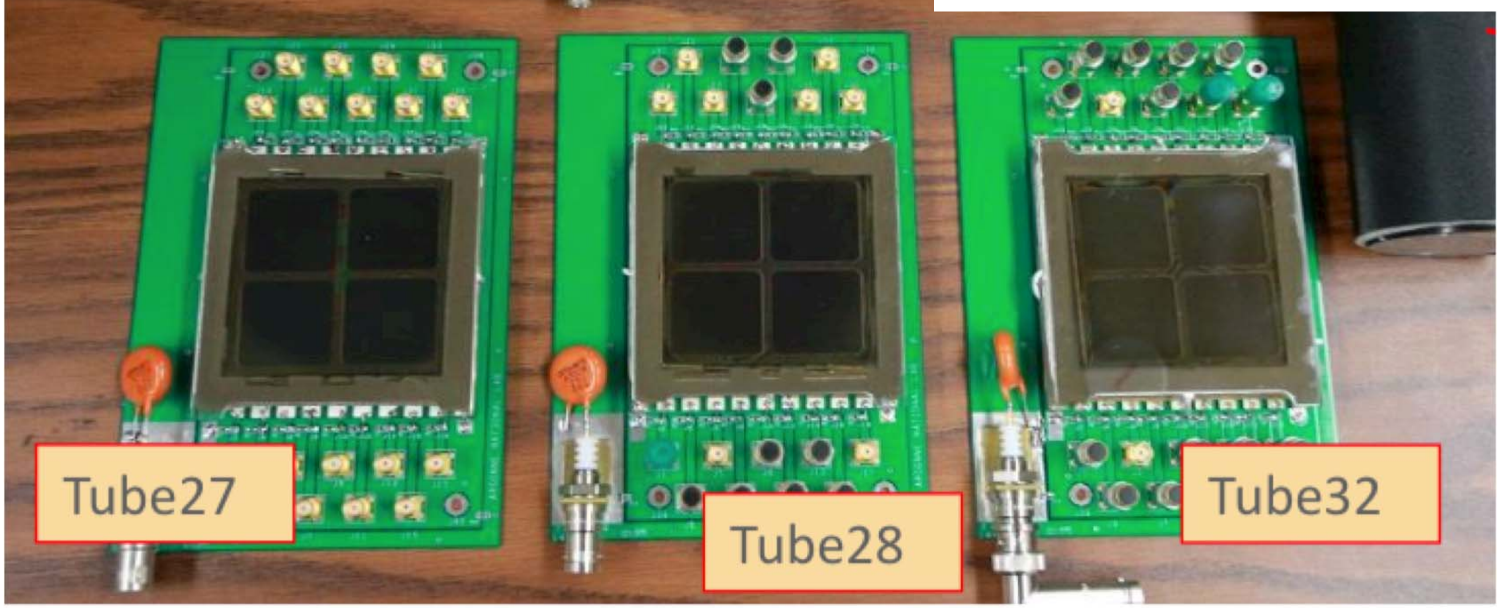
transmission line readout



15 GS/s waveform
sampling DAQ

First 6x6 cm^2 samples at ANL
Thanks to Jingbo Wang for delivering #28 to JLAB

Breaking News: Two more working samples #36 and #37



Currently Funded Tasks

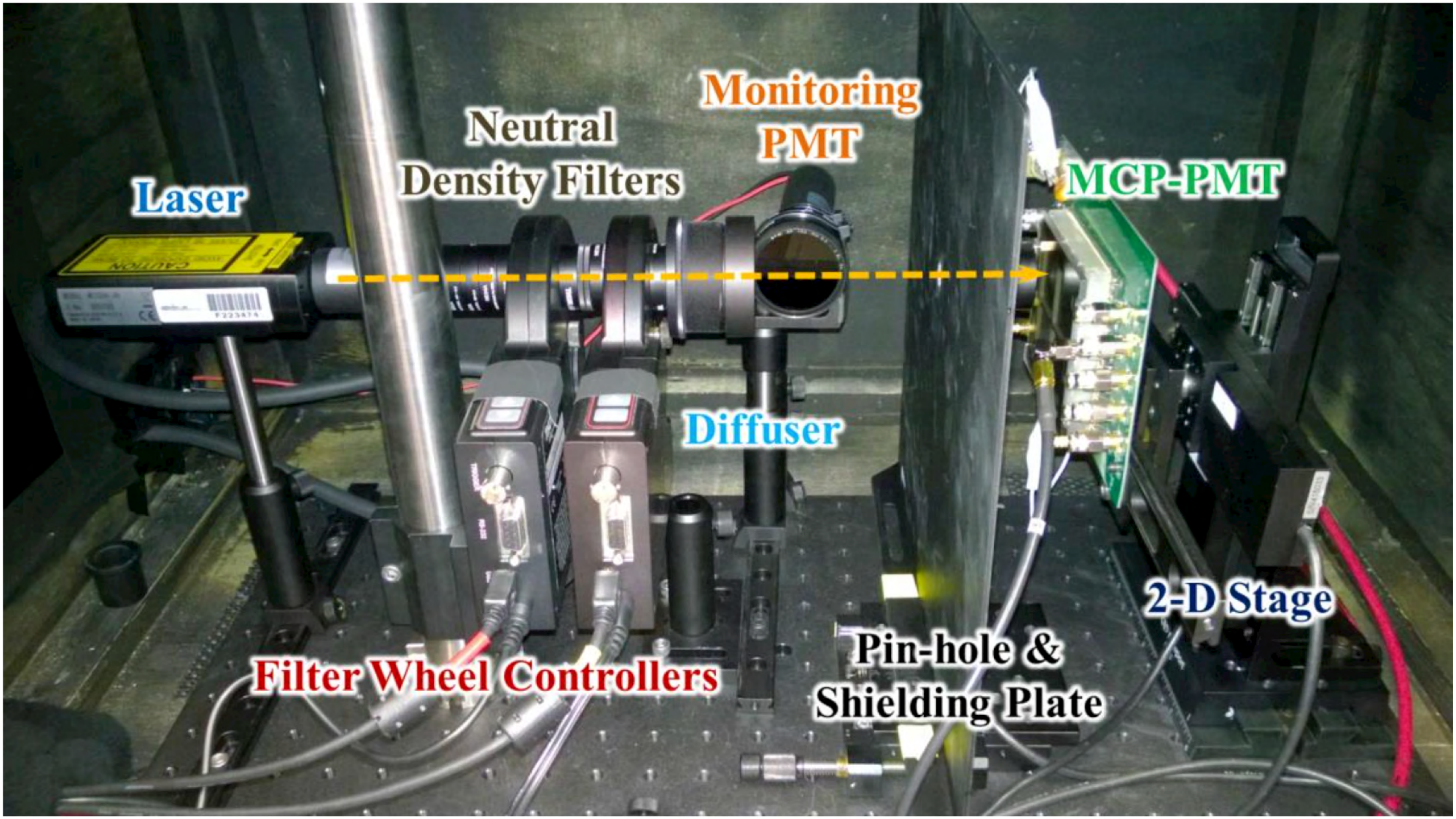
Lab Tests of the LAPPD prototype mini-sample:

- Photon detection efficiency, position resolution, rate capability
- Radiation tolerance, magnetic field effects
- Timing resolution

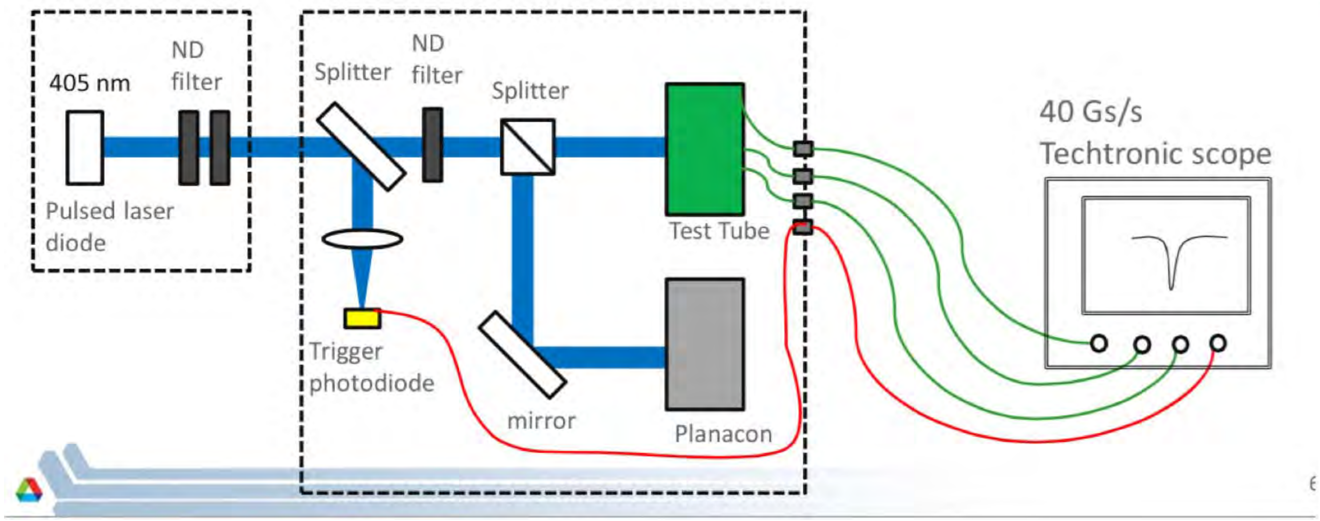
Detector Simulation:

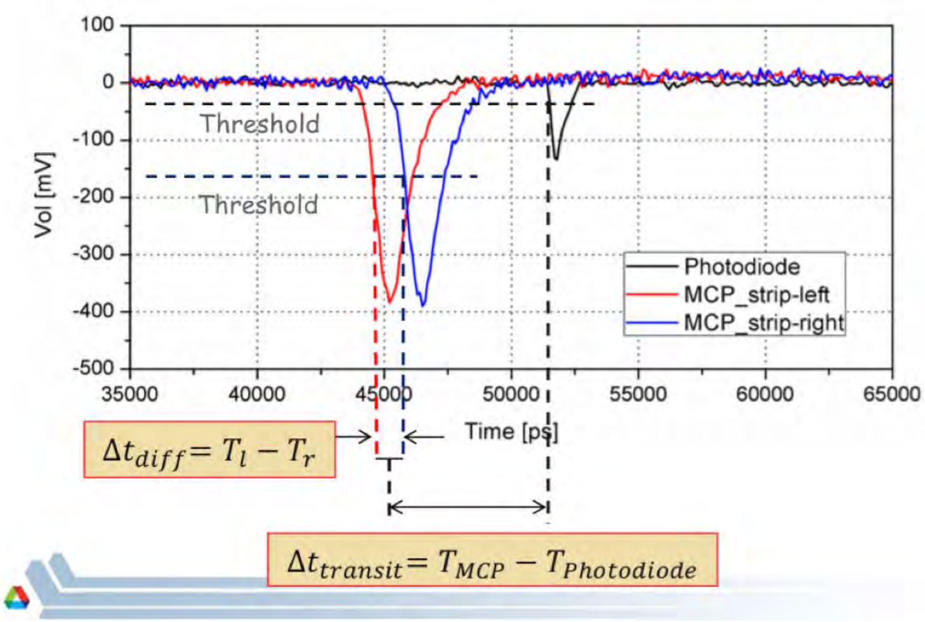
- Implementation of optical components in MEIC-GEMC with simulation in standalone mode to study requirements of optical qualities of aerogel and fresnel lens
- Evaluate response to physics events, such as phase space and occupancies
- Estimate realistic background levels for EIC environment

Test Setup for JLAB sample 28



Setup at ANL

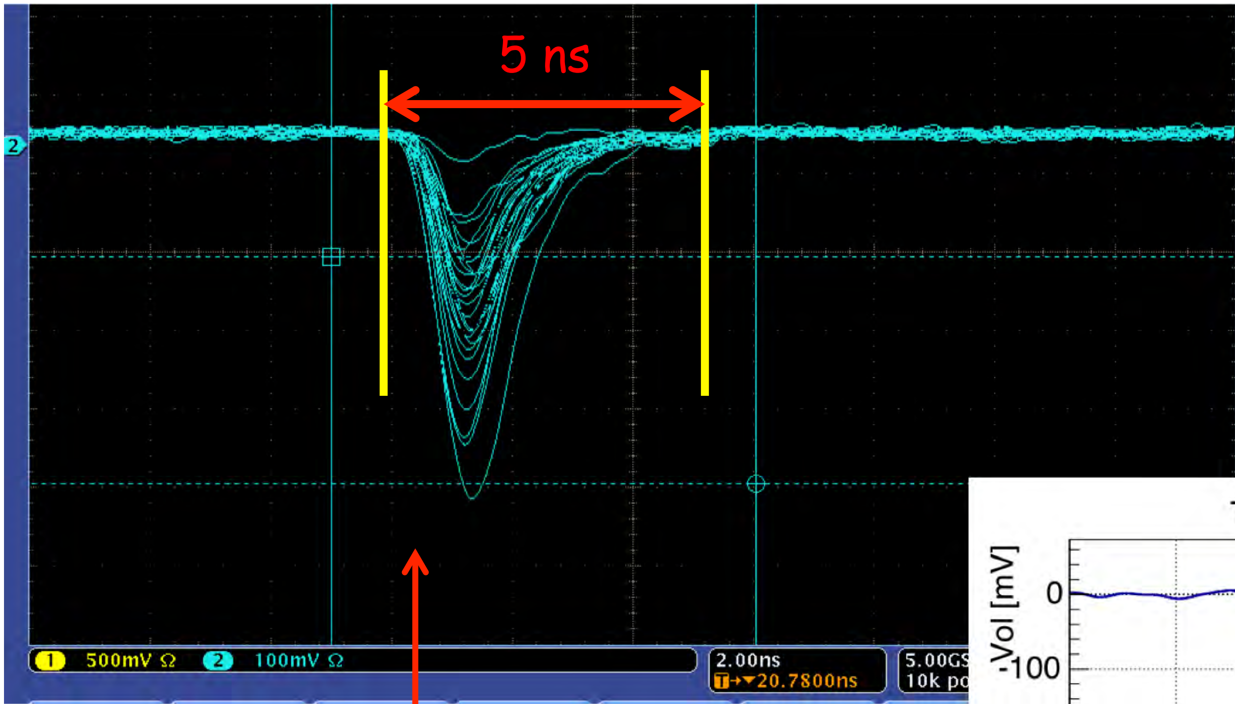




$\sigma(\Delta t_{transit})$:
Transit time spread (TTS) resolution

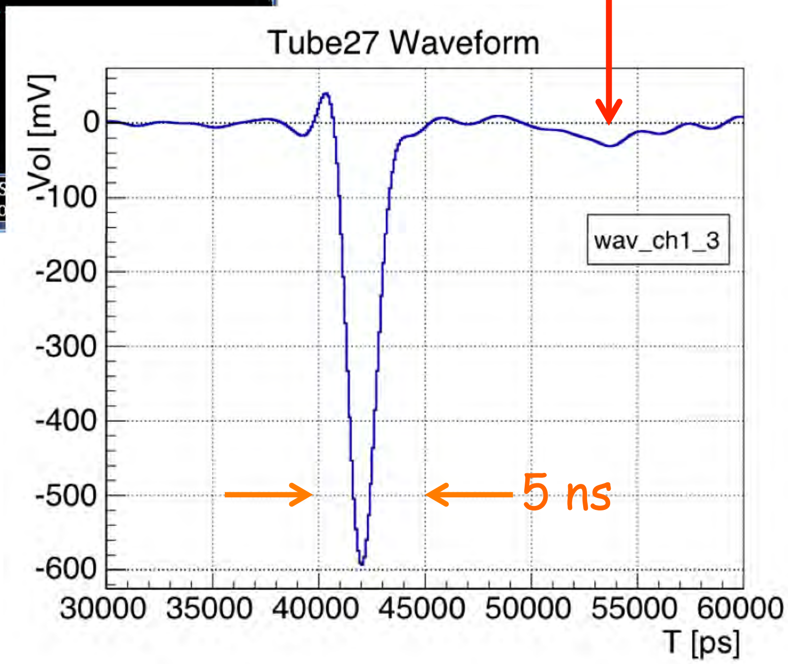
$\sigma(\Delta t_{diff})$:
Differential transit time spread resolution

Pulse comparison



JLAB sample
1 GHz BW
5 Gs/s scope

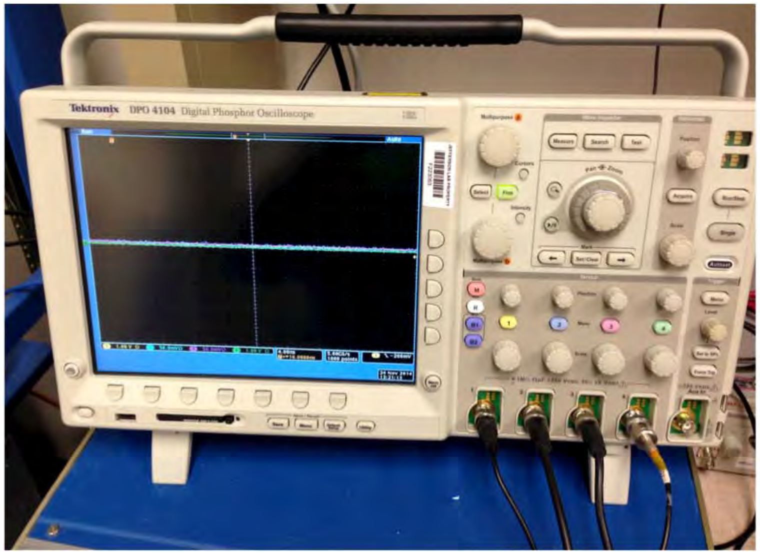
ANL sample
3.5GHz BW
40 Gs/s scope

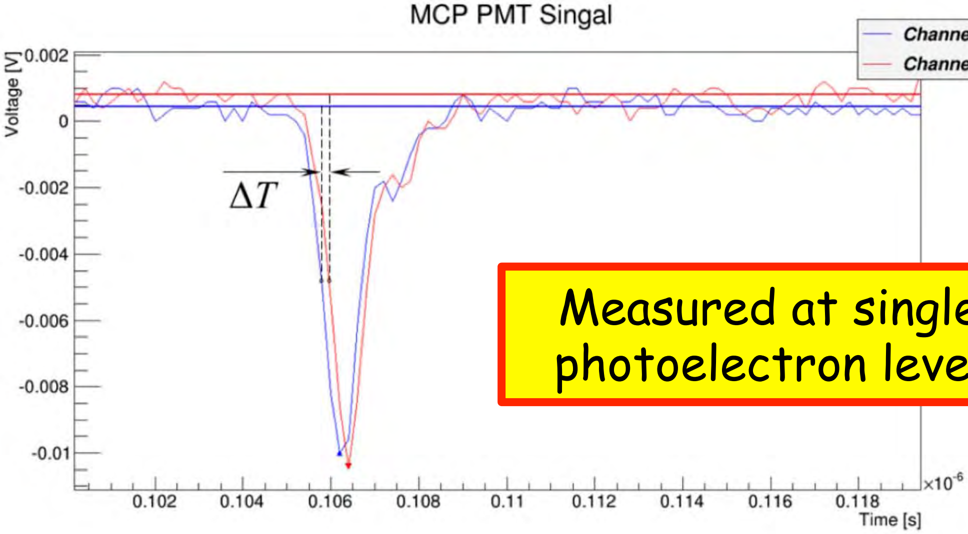


Rise time 0.75 ns

Scope limit 0.35 ns

Initial DAQ – 1 GHz BW, 5 Gs/s scope



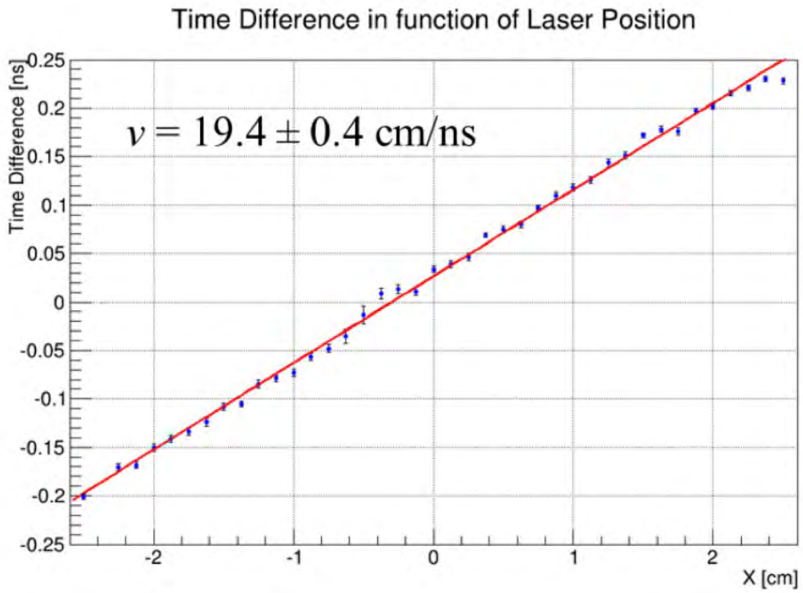


Measured at single photoelectron level

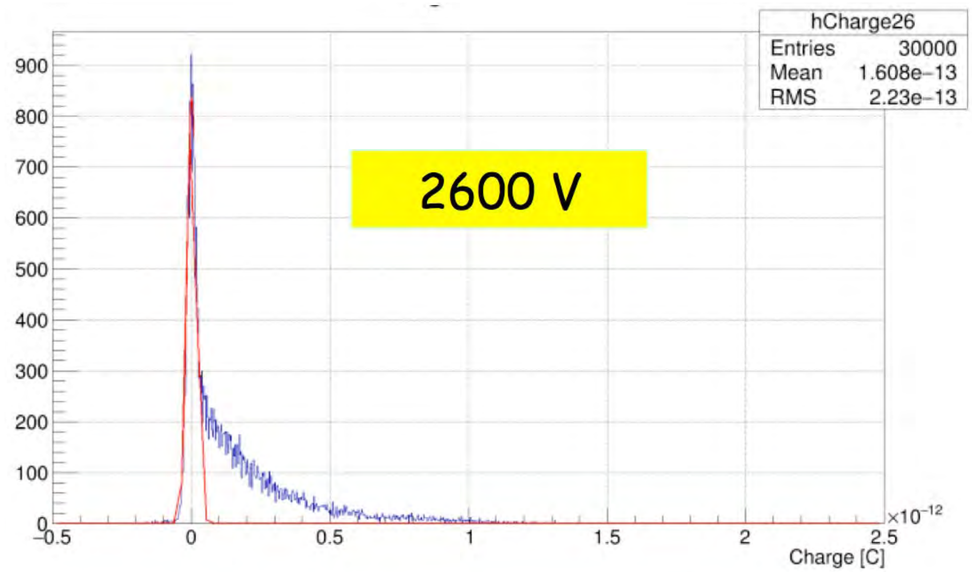
A few quick results

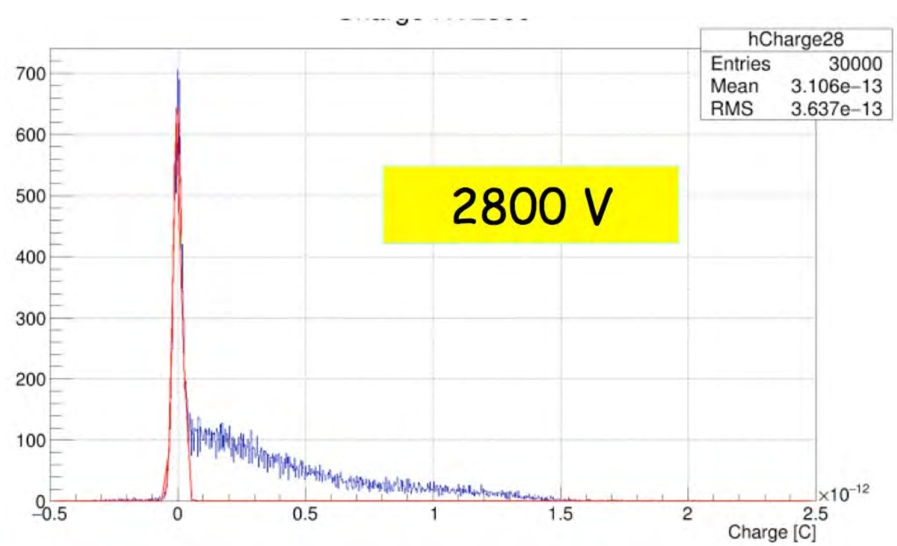
Readout strip width
4.7 mm physical
Scan FWHM = 4.5 mm

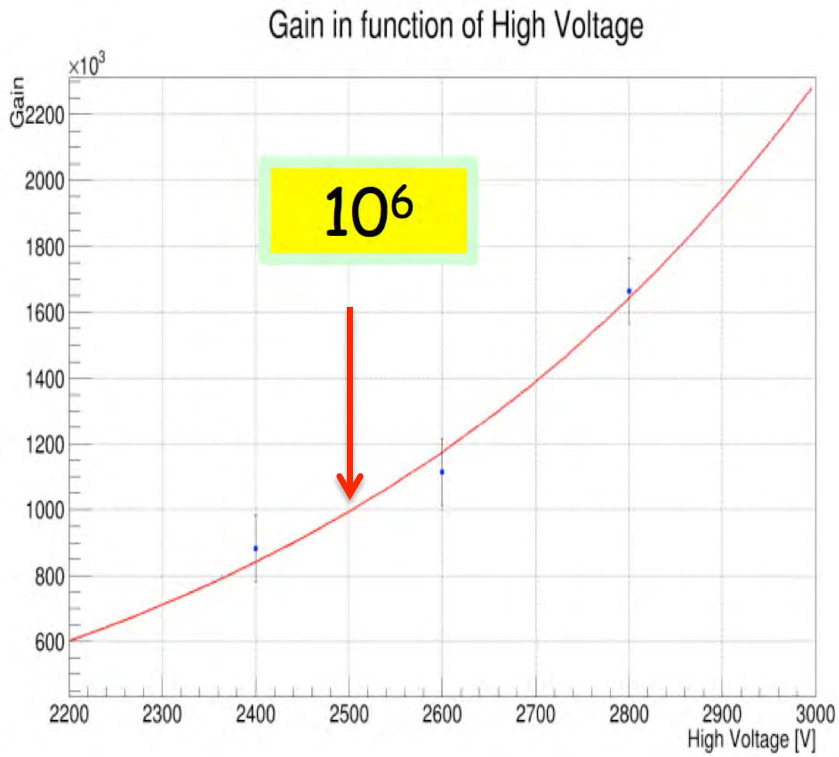
Strip Signal transmission speed
178 μm/ps (ANL)
194 μm/ps (JLAB)



Gain Estimates from SPEish spectra

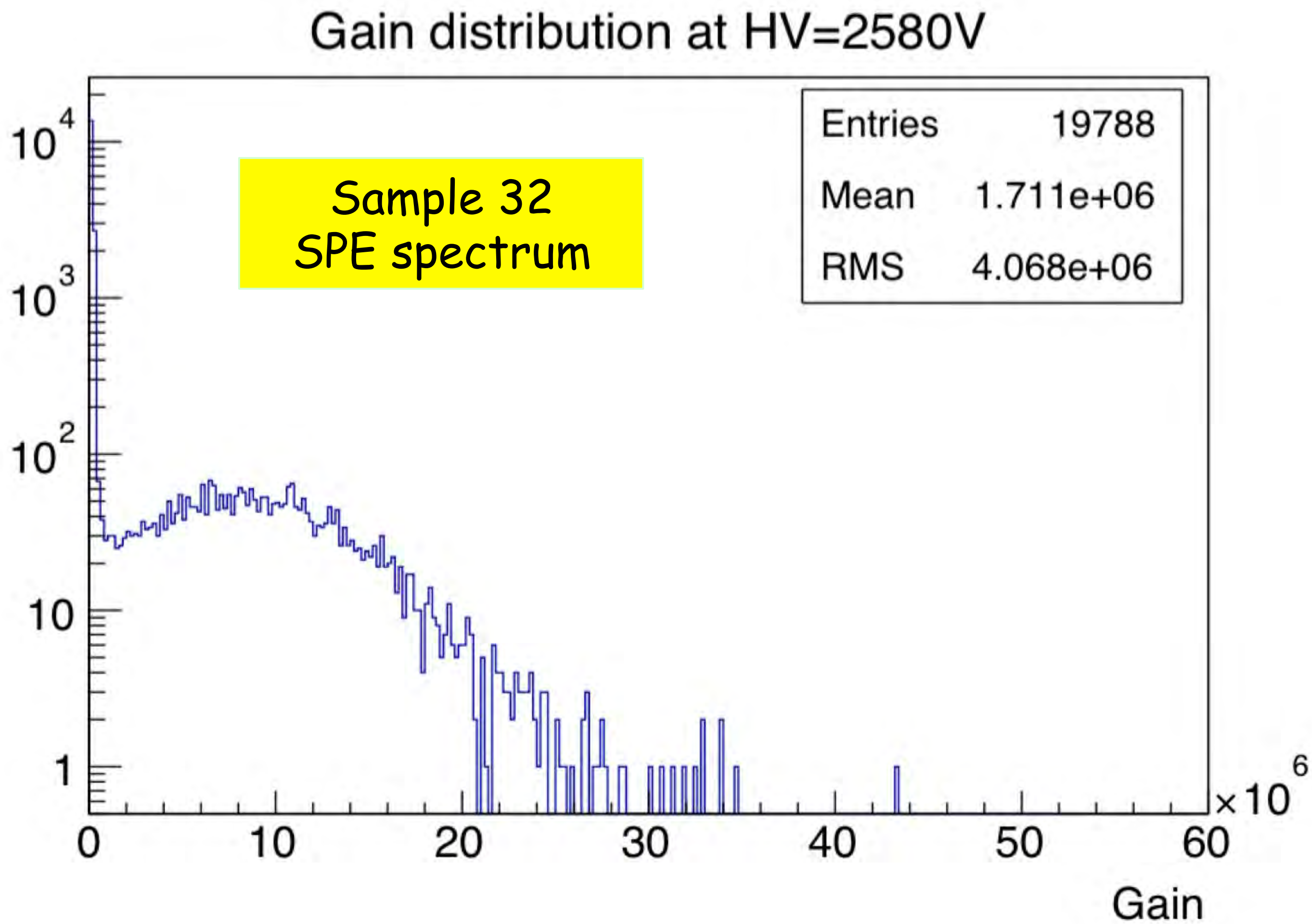






New Results from ANL

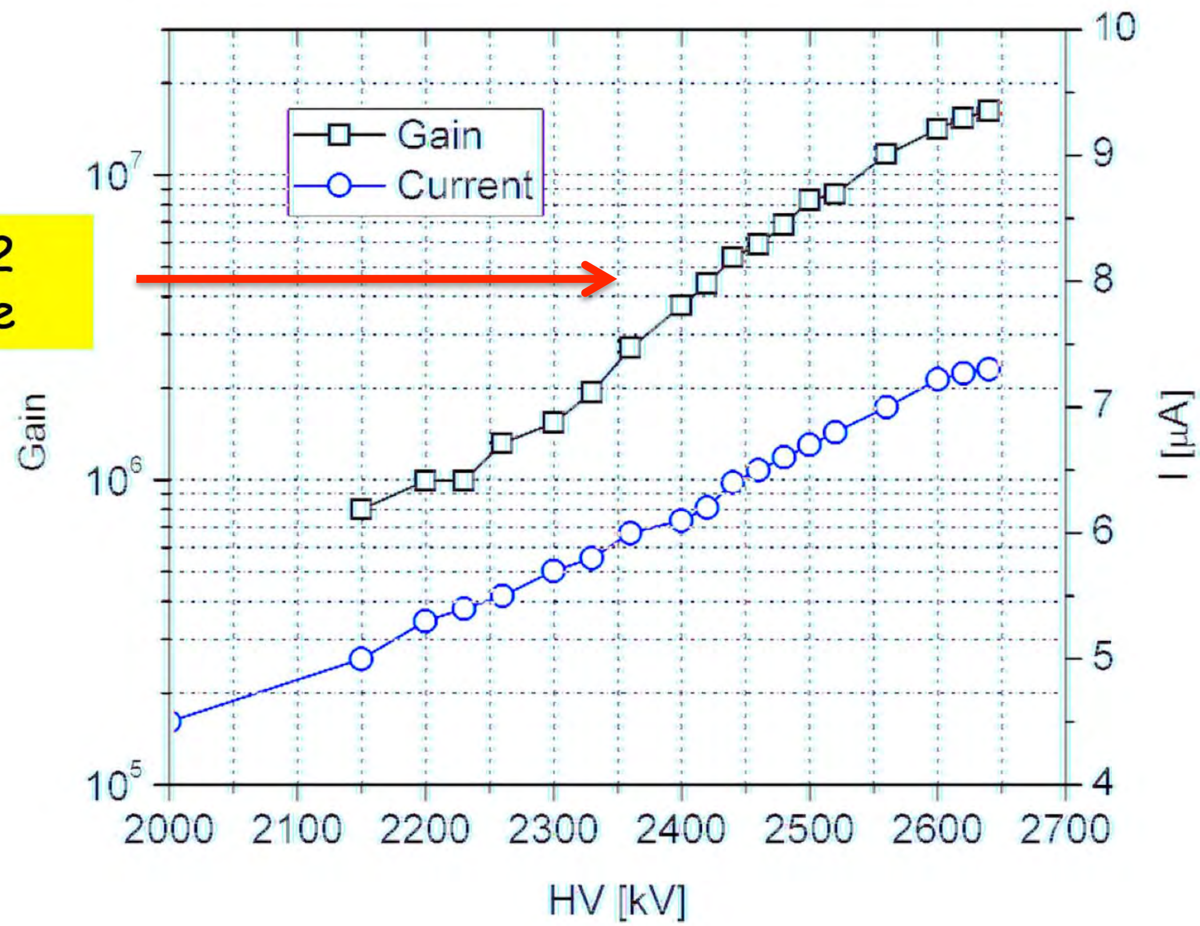
Jingbo Wang and Edward May



New Results from ANL

Jingbo Wang and Edward May

Sample 32
Gain curve

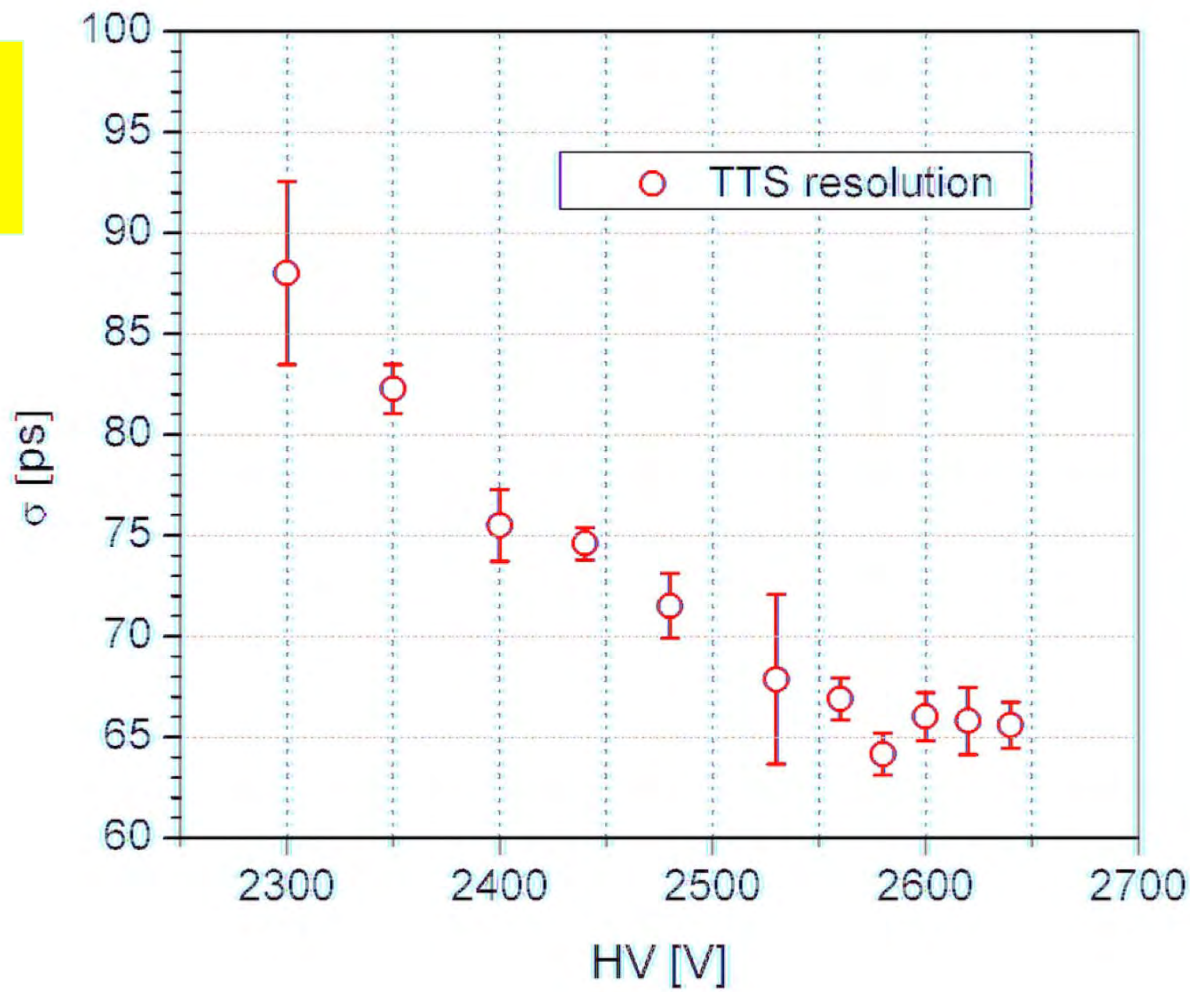


Jefferson Lab

New Results from ANL

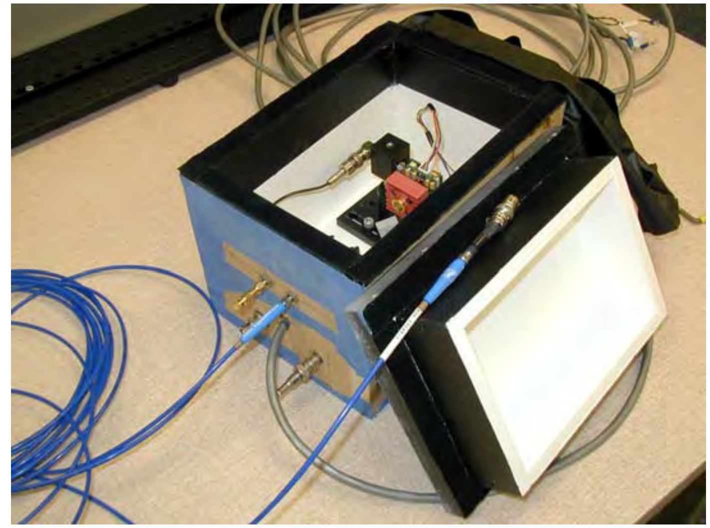
Jingbo Wang and Edward May

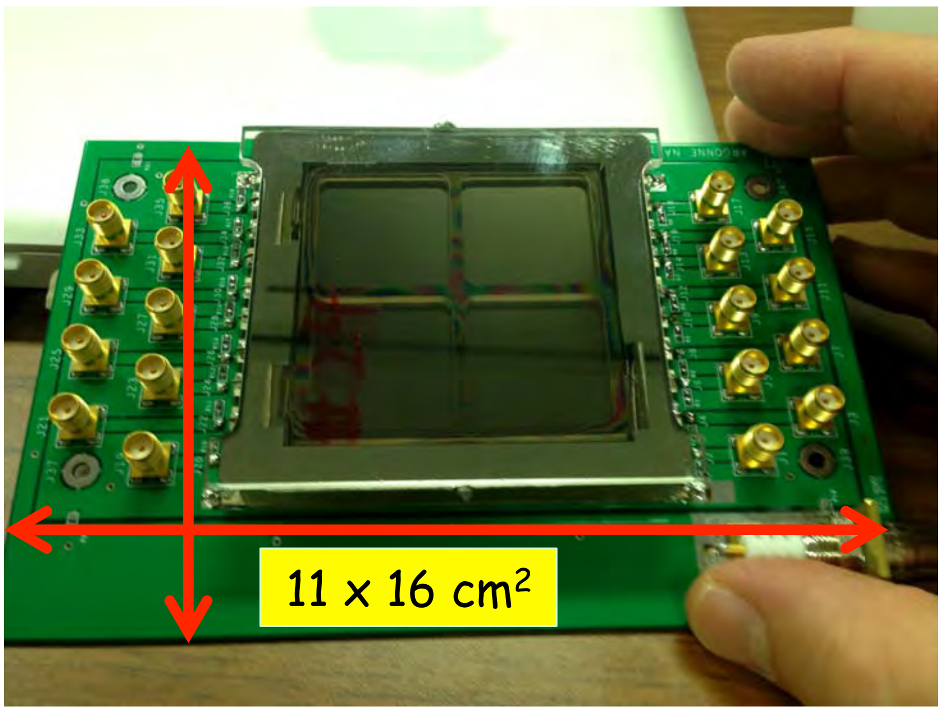
Sample 32
Timing resolution
at SPE levels

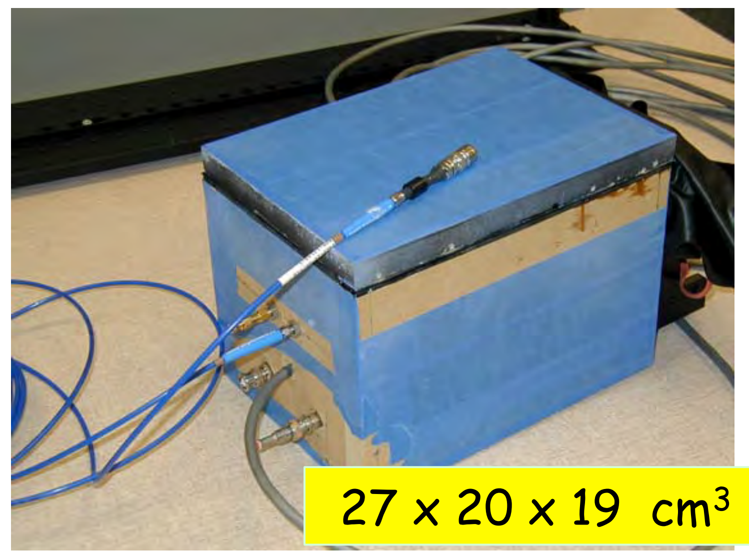


Magnetic Field Sensitivity

Place sample in mini-dark box
Need large bore high-field magnet
Candidate sites: Hall D
Helios (ANL)
U. West Virginia

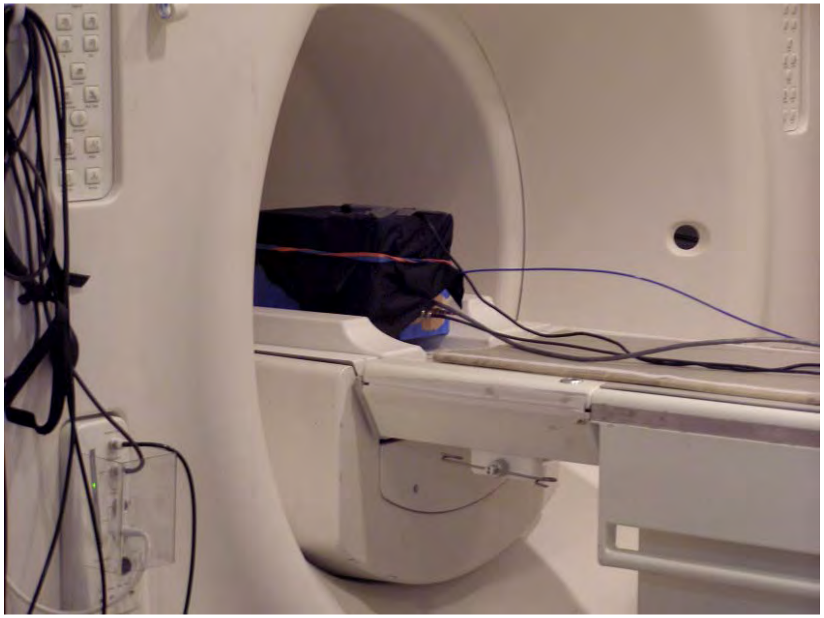






Large Bore R&D medical MRI magnet – 3 T – U.West Virginia

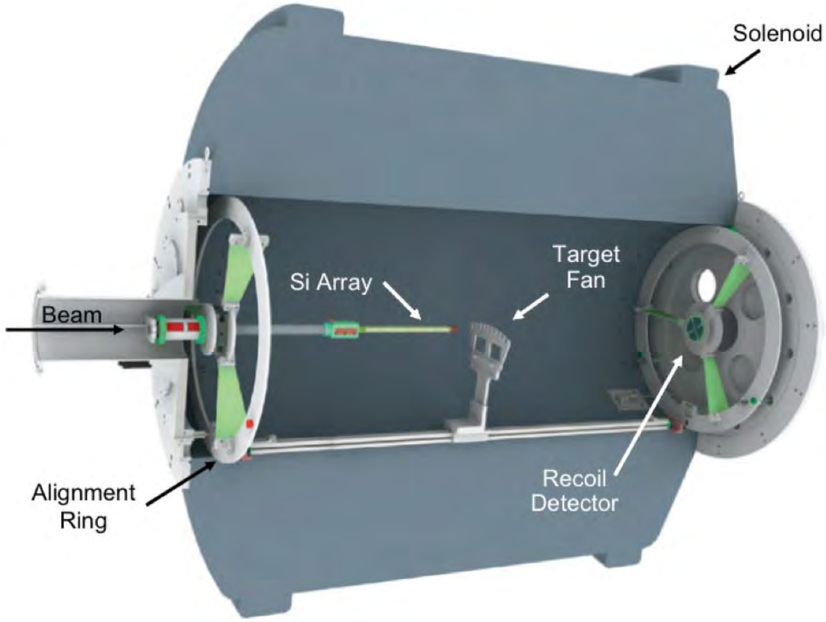
Original test of SiPM B-field immunity for Hall D GlueX experiment



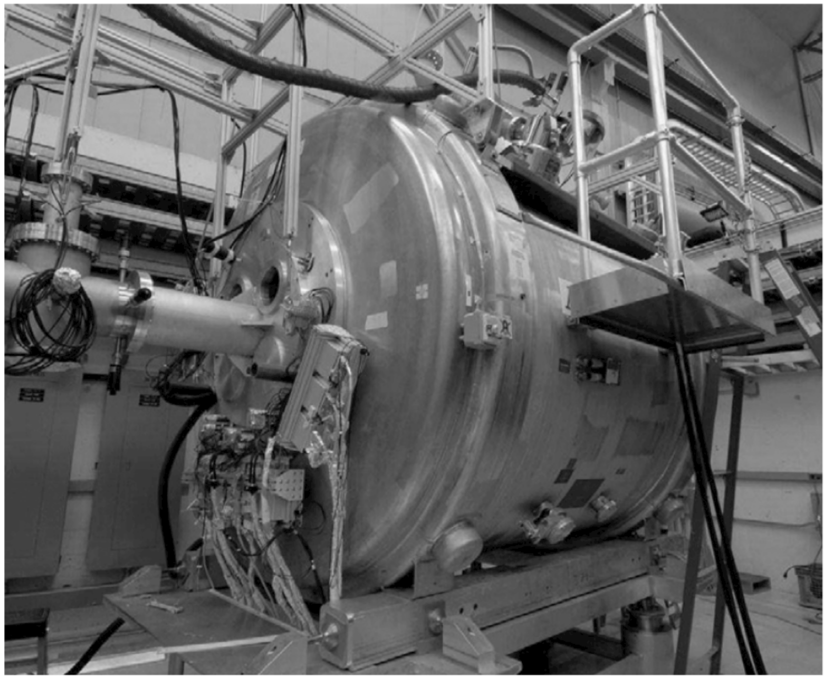
Left: Many thanks to *Dr Ray Raylman* of WVU's Radiology Department.

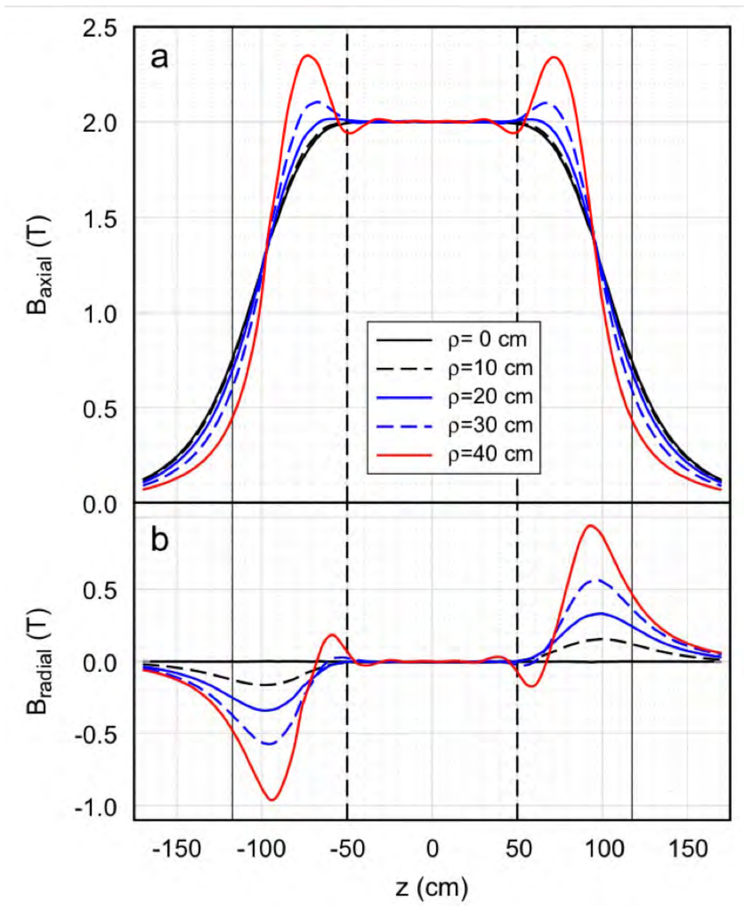
Right: Mini dark box placed on patient bed in the magnet bore.

HELIOS @ ANL



90 cm diameter bore, 2.85 Tesla





Simulation Studies

Contact:

© Maurizio Ungaro, Author of gemc

e-mail: ungaro@jlab.org

MYSQL
GDML
Plugins
TXT

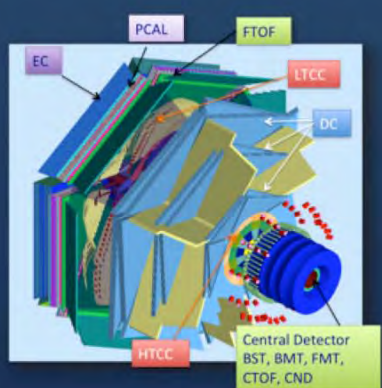
Geometry
Sensitivity
Digitization
Output

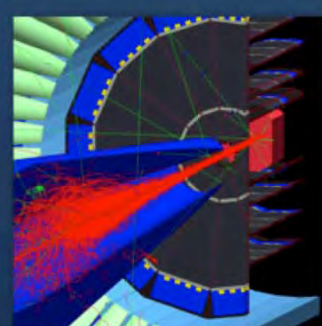
SVT
CTOF
beamline
DC

Run 27433 Conditions

Tilts, Displacements, Variations

RUN





GEMC

GEant4 Monte-Carlo

gemc is an application based on Geant4 libraries to simulate the passage of particles through matters.

The simulation parameters (geometry, fields, etc) are defined in databases (MYSQL, TXT, GDML, C++ plugins): the same ***gemc*** executable can be used for different detectors and experiments.

Platforms Supported

- Windows 7,8 (coming soon)
- Linux (32, 64)
- Mac OS X

Latest News

7/15/14
- Fixed issue affecting multiples hits on the same sensitive detector
- Fixed issue that ignored digitized type for double type variables

7/10/14
- Fixed issue that may shows on Linux when multiples materials are defined with similar names

7/9/14
- Fixed Initialization of mini_stagger_shift into hit process routine constructor

7/7/14
- Added PCAL process routine inb 2.0
- Fixed generated particle summary tags and numes
- Fixed NSTRIPS ec variable being defined in the wrong place

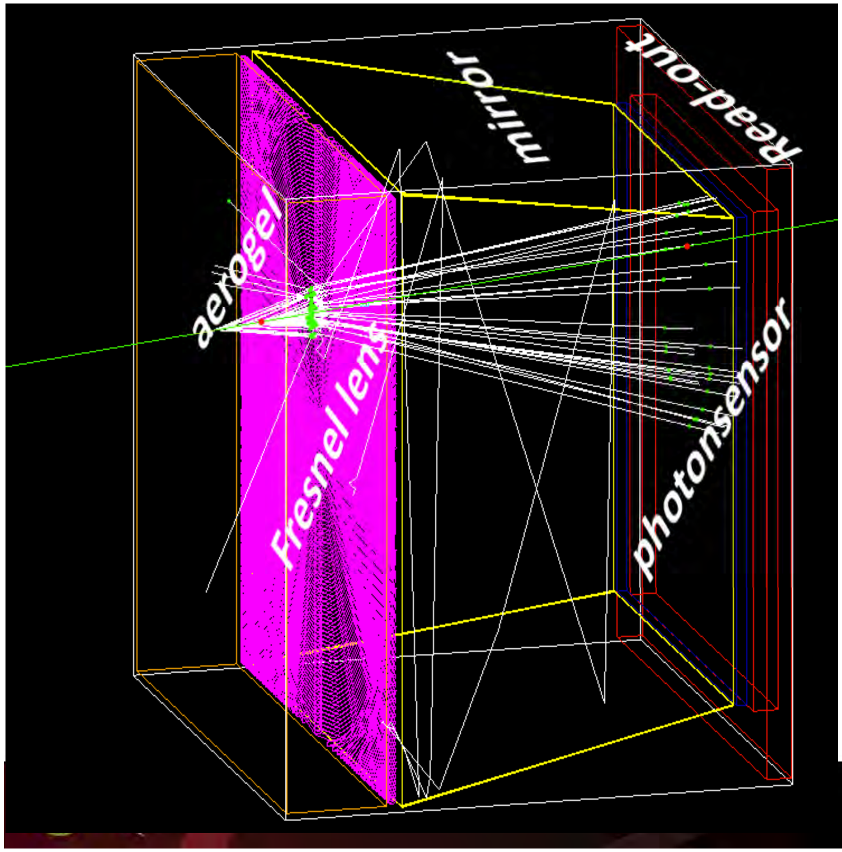
6/18/14
- fixed dipole map reading typo

6/17/14
- Added nphe in summary output. Notice: this is before any digitization.

News Archive

Simulation Studies

- Uses GEMC code by Liang Xue, Cheuk-Ping Wong (Georgia State U), Zhiwen Zhao (ODU)
- Based on C++ model code with Geant-4 libraries - simulation parameters are defined externally and can be stored in local files or in databases
- One can build a completely customized hit process routine for individual detectors with analog or digital output
- Can be used for a single detector simulation and then seamlessly merged into a whole detector simulation - refer to http://gemc.jlab.org and https://eic.jlab.org/wiki/index.php/EIC_Software

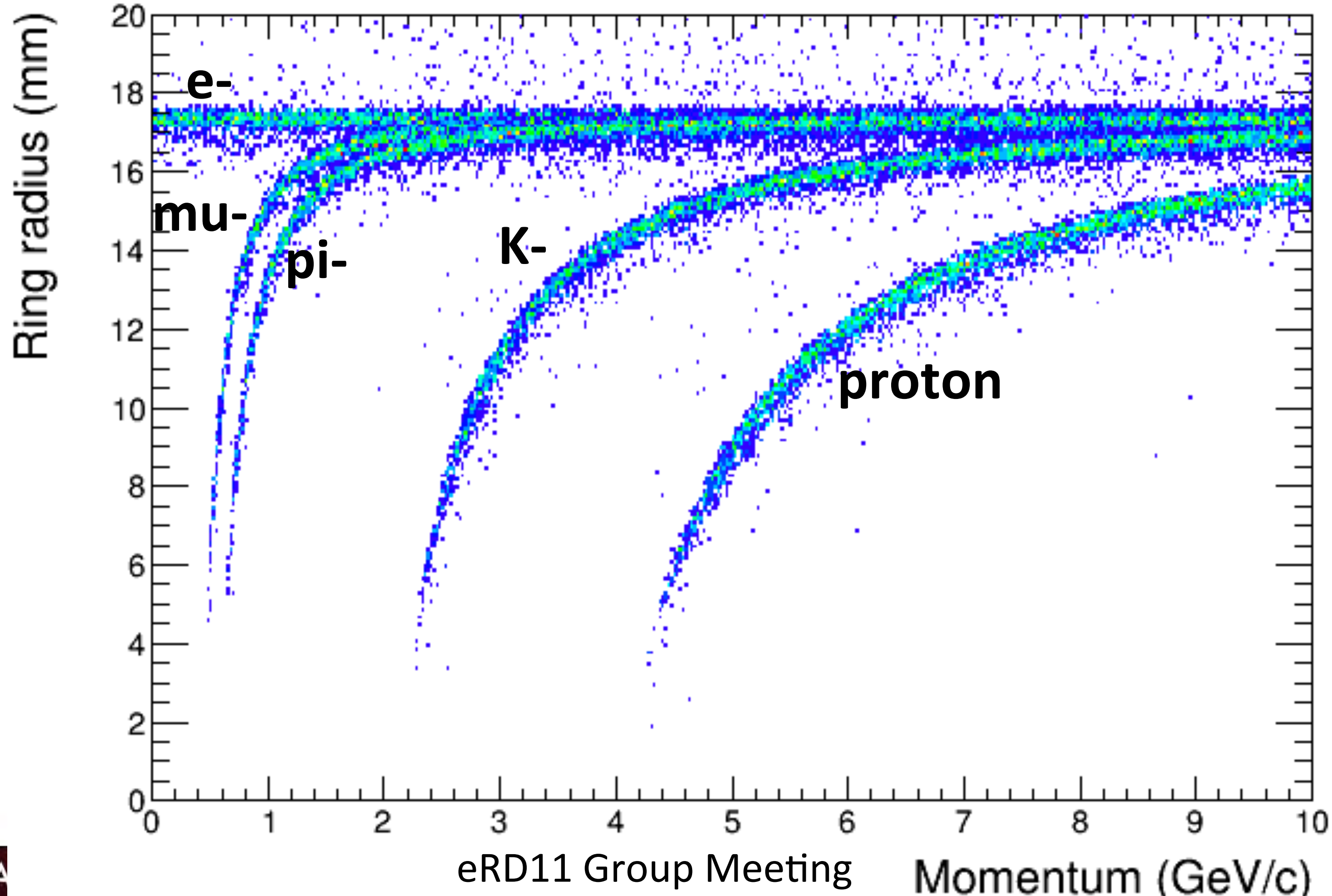


Example Model Components

aerogel (2 cm depth, 20 mg/cm^3, n=1.025)
SUVT acrylic fresnel lens (100 grooves, f=8cm)
4 mirrors on 4 sides
photodetector + readout electronics

Simulation: Perfect Case

- **10 k single e-, mu-, pi-, K-, and protons are launched along the optical axis (Z axis).**
- **Particles can be identified by correlating the "ring radius" and the momentum.**
- **Perfect case: shooting the center, no ring finder, no photosensor segmentation, no non-uniformity, no non-flatness etc.**



To Be Continued…

Lab Tests of the LAPPD prototype mini-sample:

- Continue tests with VME DAQ system
- Extract gain and QE
- High rate test
- Magnetic field test
- Neutron radiation hardness test

Detector Simulation:

- Implement detector non-uniformity, non-flatness effects in simulation.
- Properly implement the quantum efficiency for different materials of photosensor detector, and study their photon electron production.
- Extend the detector simulation with gas radiators.
- Study PID requirements of angular and momentum coverages, provide constraints on magnetic field in the EIC solenoid.
- Study realistic background rates in GEMC framework.

➔ ***Formation of PID consortium………***